INSTITUTE FOR MARINE RESEARCH
DAUIN · PHILIPPINES

Outlook Report

2023

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Front Cover Image: Becky Tooby

INSTITUTE FOR
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Right: Underwater monitoring of outplanted corals of opportunity for IMRs Functional Restoration and Growth Studies (FRAGS) project.

Photo: Dana Mcconnell

A Message from the Directors

We are pleased to present the Institute for Marine Research's 2023 Outlook Report, a reflection on the achievements and challenges of the past year.

2023 marked a significant milestone for our institute as it was our first full year back since the onset of the COVID-19 pandemic. Despite the disruptions and uncertainties, we emerged stronger and more determined than ever to fulfill our mission of unraveling the mysteries of the ocean and safeguarding its precious ecosystems.

We are proud to announce that our institute has grown in leaps and bounds over the past year. With an expanded team of dedicated researchers, we have broadened the scope of our research endeavors and accelerated progress towards our conservation goals.

Furthermore, we are thrilled to announce the expansion of our physical infrastructure to accommodate our growing community. In addition to our existing research facilities, we have inaugurated a new dormitory, classroom, and computer lab to enhance the learning and working environment for our staff and students. These new facilities will serve as incubators for collaboration, innovation, and excellence in marine research and education.

A notable highlight of our journey in 2022 was the acquisition of a grant issued by PADI, which enabled us to launch FRAGS (Functional Restoration and Growth Studies). This pioneering initiative focused on studying the use of fragmentation in the rehabilitation of artificial structures within marine environments. We are pleased to announce that in 2023, we concluded work on this project, and the findings have been compiled into a comprehensive manual now live on our website. This manual serves as a valuable resource for researchers, policymakers, and conservationists seeking to implement similar restoration efforts worldwide.

Building on the success of FRAGS, we have embarked on a new chapter of collaboration with the local dive community. By actively engaging divers in coral planting initiatives, we aim to foster a sense of stewardship and empower individuals to become champions for marine conservation. Through these collaborative efforts, we are cultivating a community-driven approach to preserving and restoring our precious marine ecosystems.

In addition to our internal research efforts, we have also welcomed researchers from various universities to study the reef ecosystems in collaboration with our institute. Their research endeavors have been instrumental in expanding our understanding of marine biodiversity, ecological dynamics, and conservation strategies. We are delighted to announce that the findings of their research can now be found on our website, serving as valuable contributions to the global scientific community and informing evidence-based conservation practices.

Furthermore, we have adopted ReefCloud, an AI-assisted software, which has expanded our research capabilities.

This innovative tool has enabled us to keep our research at the finest scale possible, providing us with deeper insights into the intricate dynamics of marine ecosystems. By harnessing the power of artificial intelligence, we are advancing our understanding of complex ecological processes and enhancing our ability to develop targeted conservation strategies.

We have strived to raise awareness about the importance of marine conservation and inspire action at both local and global levels. By empowering communities with scientific knowledge and fostering a sense of stewardship, we aim to catalyze positive change for the future of our oceans.

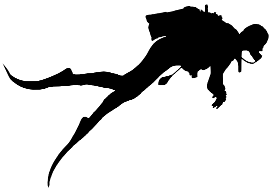
Looking ahead, we recognize that the road to marine sustainability is fraught with challenges, from climate change and habitat degradation to overfishing and pollution. However, we remain steadfast in our resolve to confront these challenges head-on, armed with the collective expertise and passion of our research community.

As we embark on the journey that lies ahead, we extend our deepest gratitude to our staff, partners, and supporters for their unwavering dedication and invaluable contributions. Together, we will continue to push the boundaries of marine research, inspire conservation action, and pave the way towards a more resilient and thriving ocean ecosystem for generations to come.

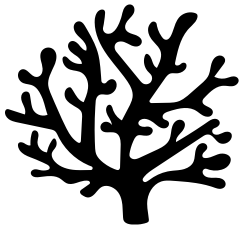
Best fishes,

Rafael Manrique &
Chelsea Waters

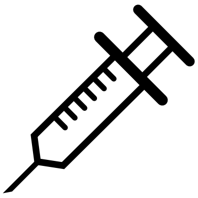
2023 in Review



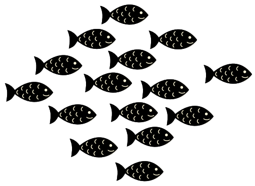
38 Surveys
completed for the Dauin long-term reef montioring project



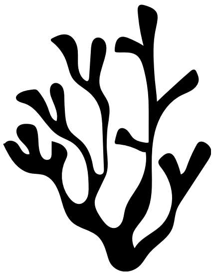
600m²
of artificial reef restored with corals of opportunity



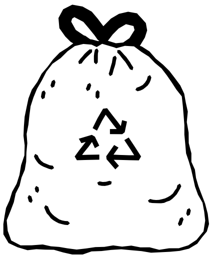
500+
Crown of Thorns Starfish injected



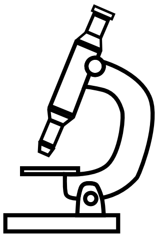
300+ hours
of EventMeasure analysis for fish abundance and biomass outputs



47 coral genera
recorded within the Municipality of Dauin



21 Dive Against Debris
dives to remove ghost nets from coral colonies



3 independent projects
conducted by IMR to further understand findings associated with the Dauin long-term reef monitoring project

2 new softwares
introduced to improve the analysis of IMRs long-term monitoring efforts (ReefCloud & RealityCapture)

1,464 reef impacts
recorded in the form of disease, bleaching, coral predation (*Drupella* spp. / COTS) and/or trash

The prevalence of these impacts and associated concerns are described herein.

The Dauin Long-Term Reef Monitoring Project

The **Dauin Long Term Reef Monitoring Project**, established in 2019, is IMR's flagship research project which spans the 13km coastline of the Municipality of Dauin (Negros Oriental, Philippines, **Figure 1**). This coastline is broken into 19 core sites with permanent transect markers, and monitored bi-annually (wet/dry season). Findings from this project determine areas of concern with regards to change in benthic composition, fish assemblages, structural complexity, and direct/indirect anthropogenic impact. The full long-term monitoring methodology is detailed in IMRs *Annual Outlook Report 2020.* The IMR Annual Outlook Reports aim to turn science into solutions, highlighting areas of concern and pin-pointing areas of management action.

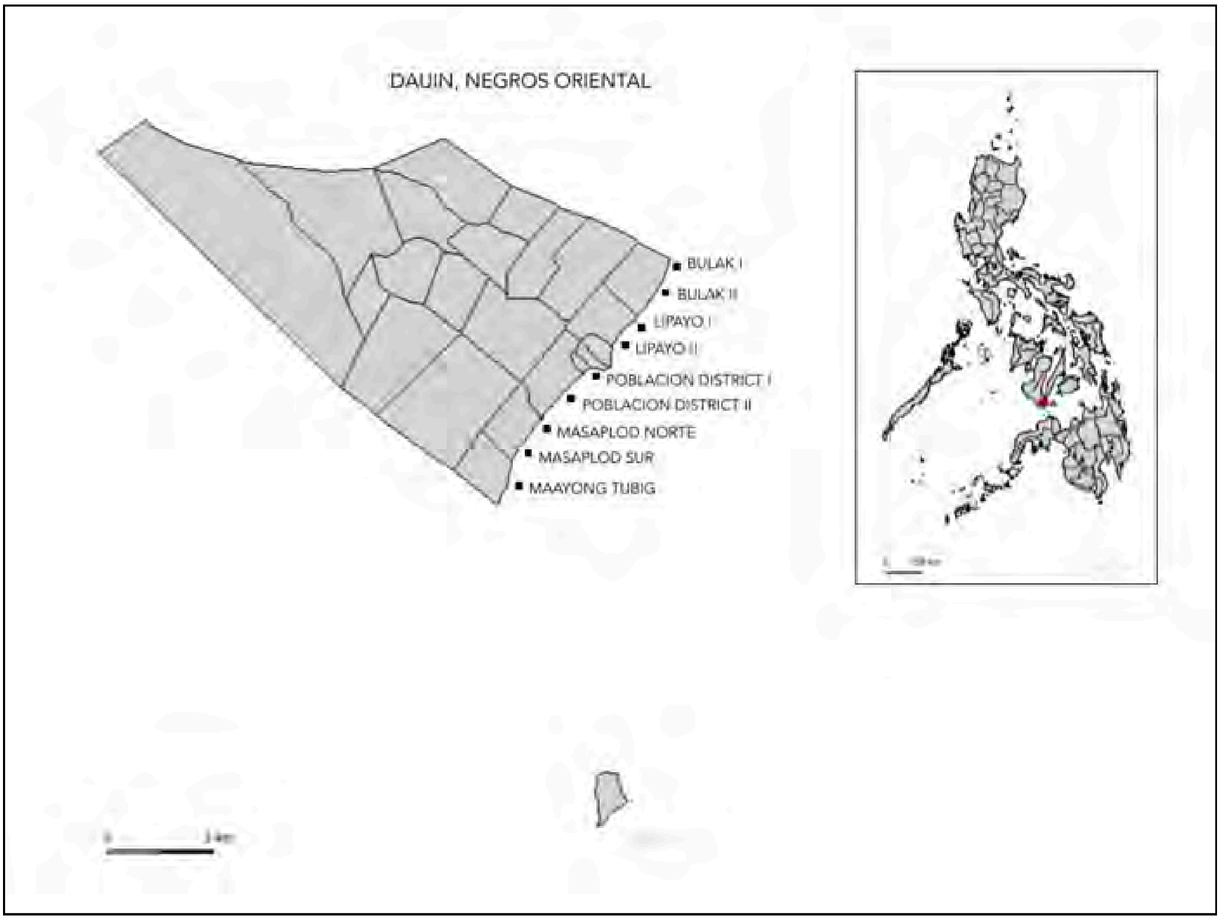


Figure 1: Survey sites monitored bi-annually as per IMRs long-term reef monitoring project, located in Dauin (Negros Oriental, Philippines)

2023 Impact Summary

Municipality of Dauin

The most prevalent impact recorded in 2023 from IMRs long-term reef monitoring project was Porites Ulcerative White Spot with a mean frequency of 17.6 per 100m^2 (SE ±17.9; **Figure 2**). This is a change from last year which saw coral bleaching as the most common impact. Bleaching has reduced since 2022 from 12.8/100m^2 (SE±12.8) to 11.1/100m^2 (SE ± 10.2) indicating that there was less bleaching in 2023 than 2022. The mean frequencies have large standard deviations, which suggests a great deal of variability within the survey sites and depths. Porites Ulcerative White Spot was the most common disease occurring within the DLTRMP, with the mean frequency of other hard coral disease dropping in 2023 to 1/100m^2 (SE±0).

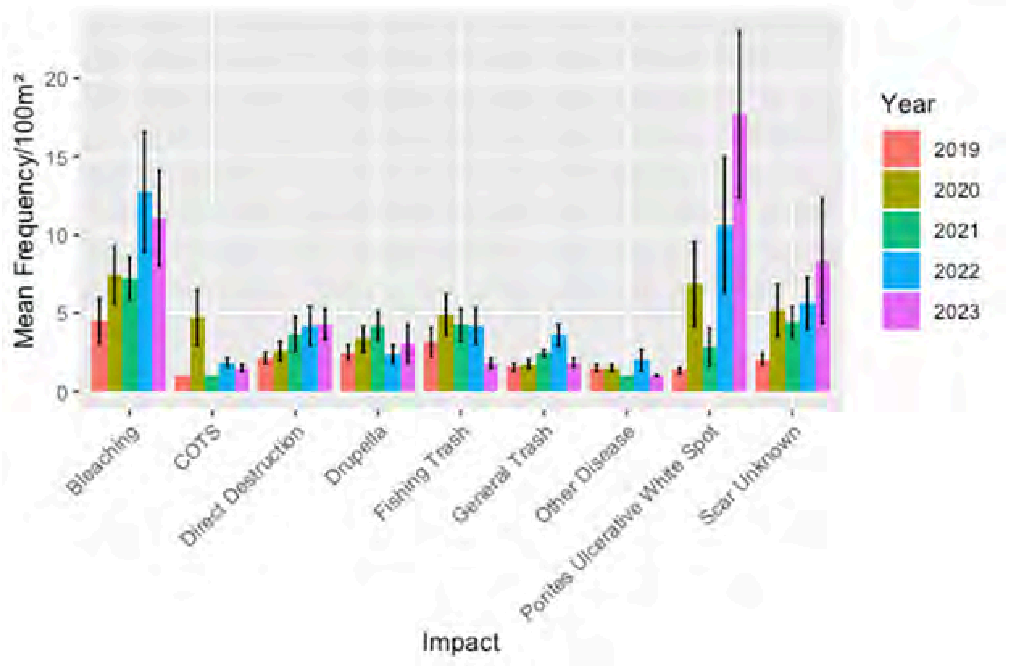


Figure 2: Fluctuations in disease prevalence since the estiblishment of IMRs long-term reef monitoring project in 2019.

Porites Ulcerative White Spot Disease

What is Porites Ulcerative White Spote Disease?

Porites Ulcerative White Spot (PUWS) is a disease found largely on stony corals of the genera *Porites* spp. The first recorded sighting of PUWS was in Negros Oriental (Philippines) in 1996, becoming widespread by 1998 in the Central Philippines (1). Its distribution now includes Indonesia, Thailand and other parts of the Indo-Pacific (2,3). PUWS is characterised by discrete, bleached, and rounded lesions of approximately 3-5mm diameter (1). These lesions will either recover (regain its symbiotic algae) or will coalesce with nearby lesions which will eventually spread and kill the whole colony, albeit relatively slowly, at which point any recovery is unlikely (1). Prevalence has been shown to be positively correlated with human population and mean disease severity (4).

Reports of PUWs in Dauin (epicentre of PUWS emergence) has been at relatively low levels (>5% of all Porites colonies on the reef) between 1996 - 2003 (4,5) . Since these reports, there has been little research into PUWS within the Dauin area until 2019 with the establishment of IMR's long-term reef monitoring project. PUWS has been recorded in IMR's long-term monitoring dataset since the inception of IMR in 2019 (**Figure 3**); suggesting its presence in Dauin has persisted since 2003 (4).

History of Spread in Dauin

Since the establishment of IMRs long-term reef monitoring project in 2019, the spread of PUWS has been heavily documented (**Figure 3**):

2019: PUWS recorded at **low levels** at **Poblacion I** (0.06/100m^2) and **Maayong Tubig** (0.01/100m^2).
2020: PUWS now recorded at **Poblacion I** & **II**, **Masaplod Sur**, and **Bulak I**.
2021: PUWS spread into **Masaplod Norte** and **Lipayo I Norte**
2022: PUWS recorded at every survey site, with 10.6m^2 of *Porites* spp. infected throughout Dauin
2023: PUWS recorded at every survey site, with 11m^2 of infected *Porites* spp. recorded throughout Dauin

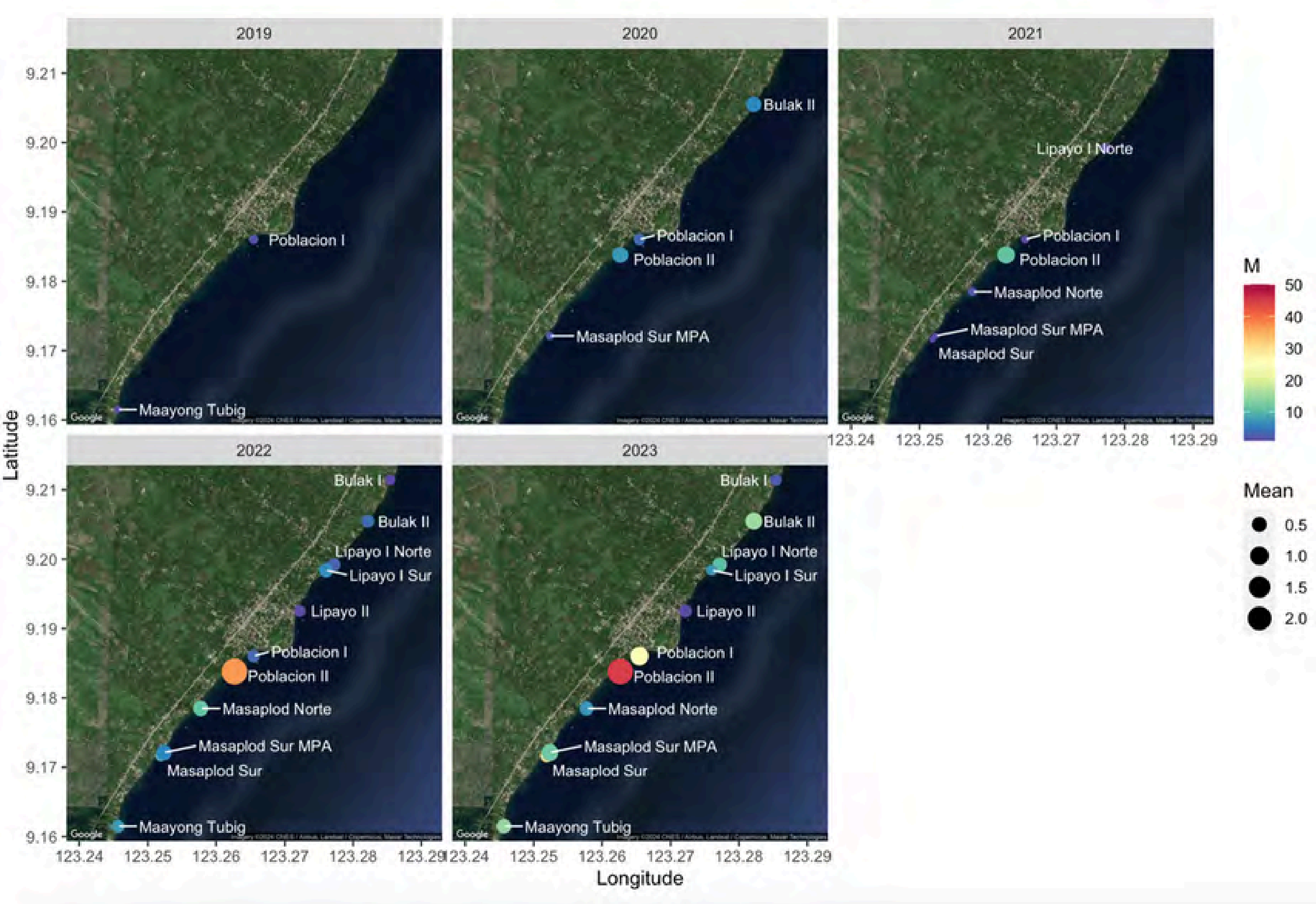


Figure 3: Mean prevalence of PUWS as number of infected colonies per 100m^2 shown as colour and infected area in m^2 per 100m^2 as size for each dive site that IMR surveys from 2019-2023.

2023 PUWS Status

The most prevalent sites for PUWS are Poblacion I and II . Per 100m^2 of reef in 2023, Poblacion I has a mean area of 0.9m^2 of infected *Porites*, and Poblacion II has 1.8m^2. This is an increase of 1514.2% and 2143.4%, respectively, since the beginning of IMR's monitoring. These two sites also have the highest proportion of *Porites* spp. per 100m^2 of all IMR's study sites, making it essential that we monitor these sites as the disease progresses (**Figure 4**).

Masaplod Norte, has one very large colony (>6m^2) that has been infected with PUWS since the start of 2023 . It is considered an outlier and has not been counted in our analysis thus far. The mean area of infected Porites spp. for Masaplod Norte in Wet season 2023 without the outlier is 0.5m^2 and the mean frequency of infected colonies is 10.5 (SE +- 3.5).

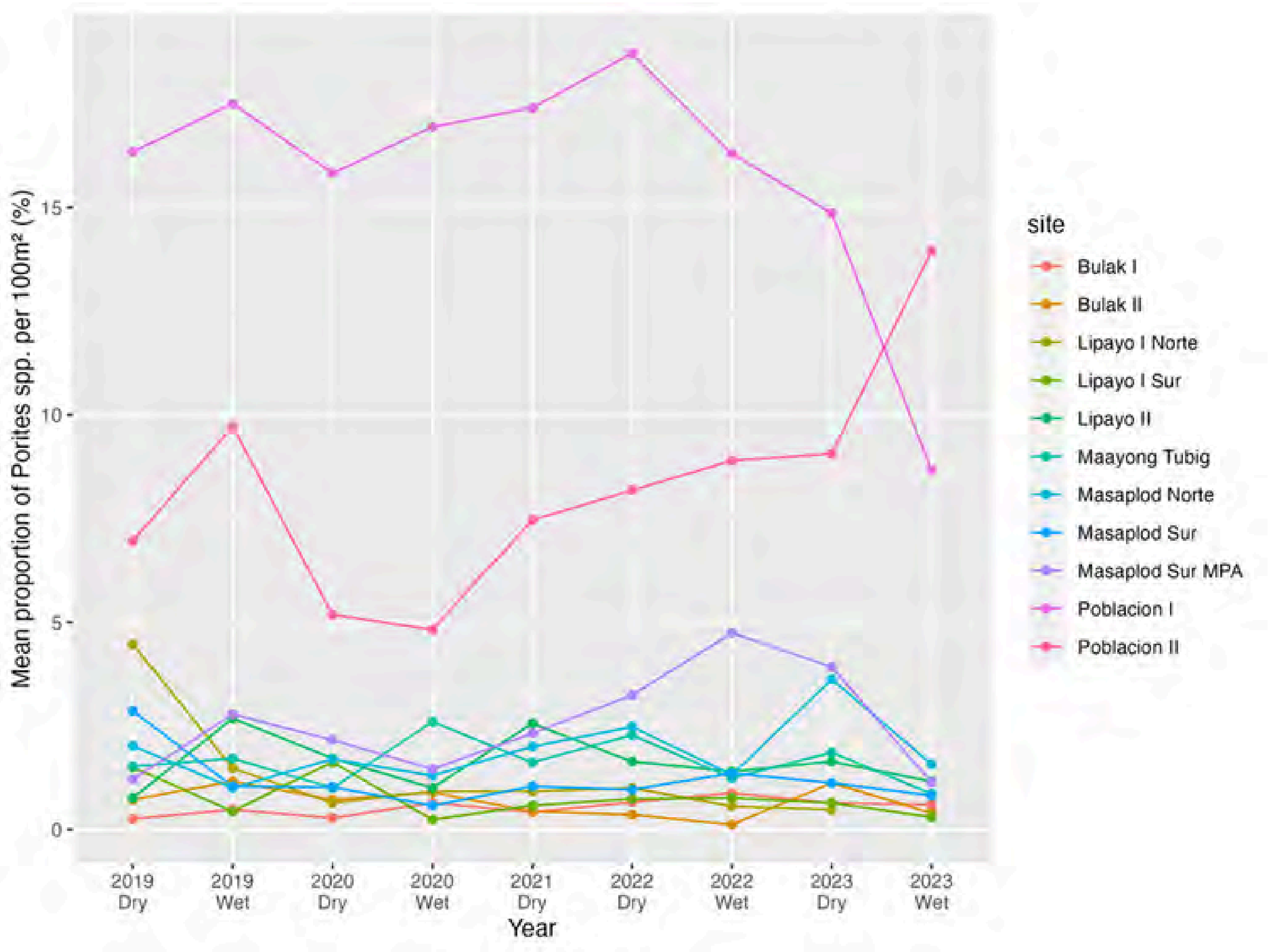
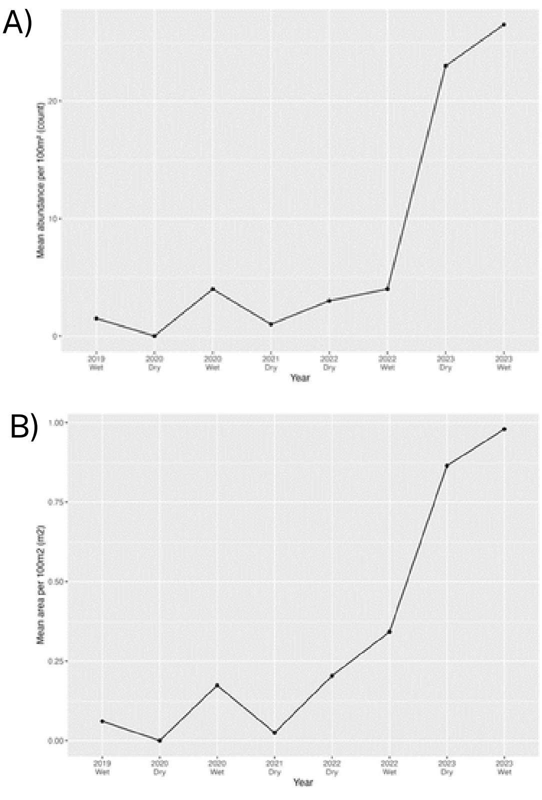


Figure 4: Mean proportion of Porites spp. per 100m^2 (100%) from 2019 Dry Season to 2023 Wet Season, separated by survey sites.

Site Spotlight #1: Poblacion I

Prior to 2023, prevalence, measured as the mean number of colonies infected per $100m^2$, was low, ranging from 1 to 6 infected colonies. In 2023, this number increased sharply, to 26.5 by the end of 2023 (**Figure 5a**). Mean size of colonies per $100m^2$ is increasing at the same rate as the mean number of infected colonies, peaking at the end of 2023 at $0.98m^2/100m^2$ (**Figure 5b**). Since the start of monitoring, the infected area at Poblacion I has increased by 1514.3%. This is a significant increase in the size of the colonies infected, implying that not only is the number of infected colonies increasing, but so are the sizes of the colonies.

Poblacion I has the highest mean proportion of *Porites*/$100m^2$ for all of our survey sites at 14.9% by the end of 2023. The levels of *Porites* spp. (infected and healthy) has decreased by 6% between Wet and Dry Seasons for 2023, continuing a downward trend that began at the beginning of 2022 (**Figure 5c**). However there is no significant increase in Recently Dead Coral or Dead Coral with Algae in our data, nor is there any trend with Turf Algae levels over time (**Figure 5c**). Furthermore, as the mean size of infected colonies and the mean number of infected colonies are increasing and not decreasing, it does not suggest that there has been mortality from PUWS yet, unsurprising given the slow mortality rate of the disease (1). Therefore we cannot say for certain that this decrease in abundance of *Porites* spp. is due to mortality from PUWS, and further research and continued monitoring is required.



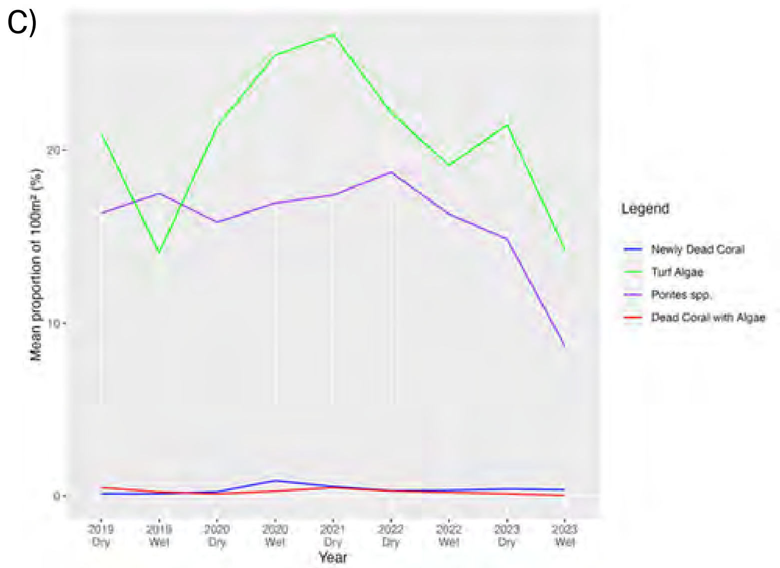


Figure 5. A) Mean abundance of *Porites* Ulcerative White Spot (PUWS) per $100m^2$ for survey site Poblacion I, B) Mean area infected by PUWS per $100m^2$ measured in m^2, and C) Mean proportion of $100m^2$ of *Porites* spp., Turf Algae, Newly Dead Coral, Dead Coral with Algae throughout 2019-2023 for survey site Poblacion I.

Site Spotlight #2: Poblacion II

Poblacion II is a popular dive site within the centre of Dauin, located in the barangay Poblacion. PUWS was first reported in Poblacion II in the beginning of 2020 and it has steadily increased in prevalence, peaking at the end of 2022 with 3.4m^2/100m^2 of infected colonies (**Figure 6a**). Since 2022, there has been a decline in the area of infected colonies (**Figure 6b**). Further monitoring would be required to determine if this trend continues, and whether it suggests either mortality or recovery from PUWS. At the end of 2023, there was a mean count of 34.5/100m^2 and mean area of 1.8m^2/100m^2 for Poblacion. Looking at the data from benthic assays, levels of *Porites* spp. have increased in 2023 up to 14%/100m^2, making it the site with the second highest proportion of *Porites* spp. per 100m^2 survey transect (**Figure 6c**). The increase in *Porites* spp. coral cover could suggest that recovery is occurring on the reef at Poblacion II, as the prevalence of the disease is also falling and the levels of Turf Algae, Recently Dead Coral, and Dead Coral with Algae has remained constant.

Despite the current decline, Poblacion II has had the highest prevalence of PUWS since 2020, the same year it was first reported at the site. At the end of 2023, Poblacion II had nearly double the mean size of the next most prevalent size (Poblacion I, see previous section). Since first reported, the mean surface area of infected Porites per 100m^2 has increased by 2143.4%. Further research is necessary to determine whether the shift is due to recovery from PUWS or from other factors.

A)

B)

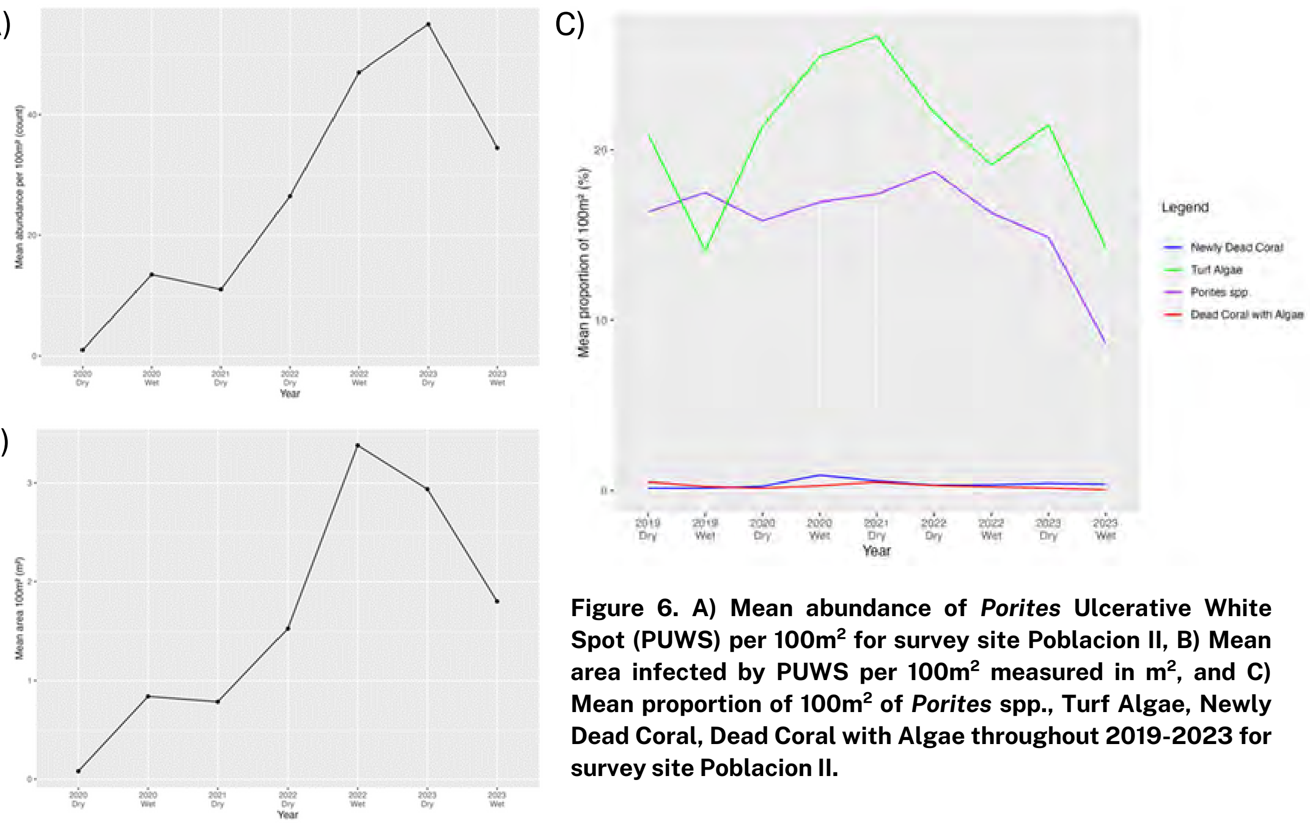
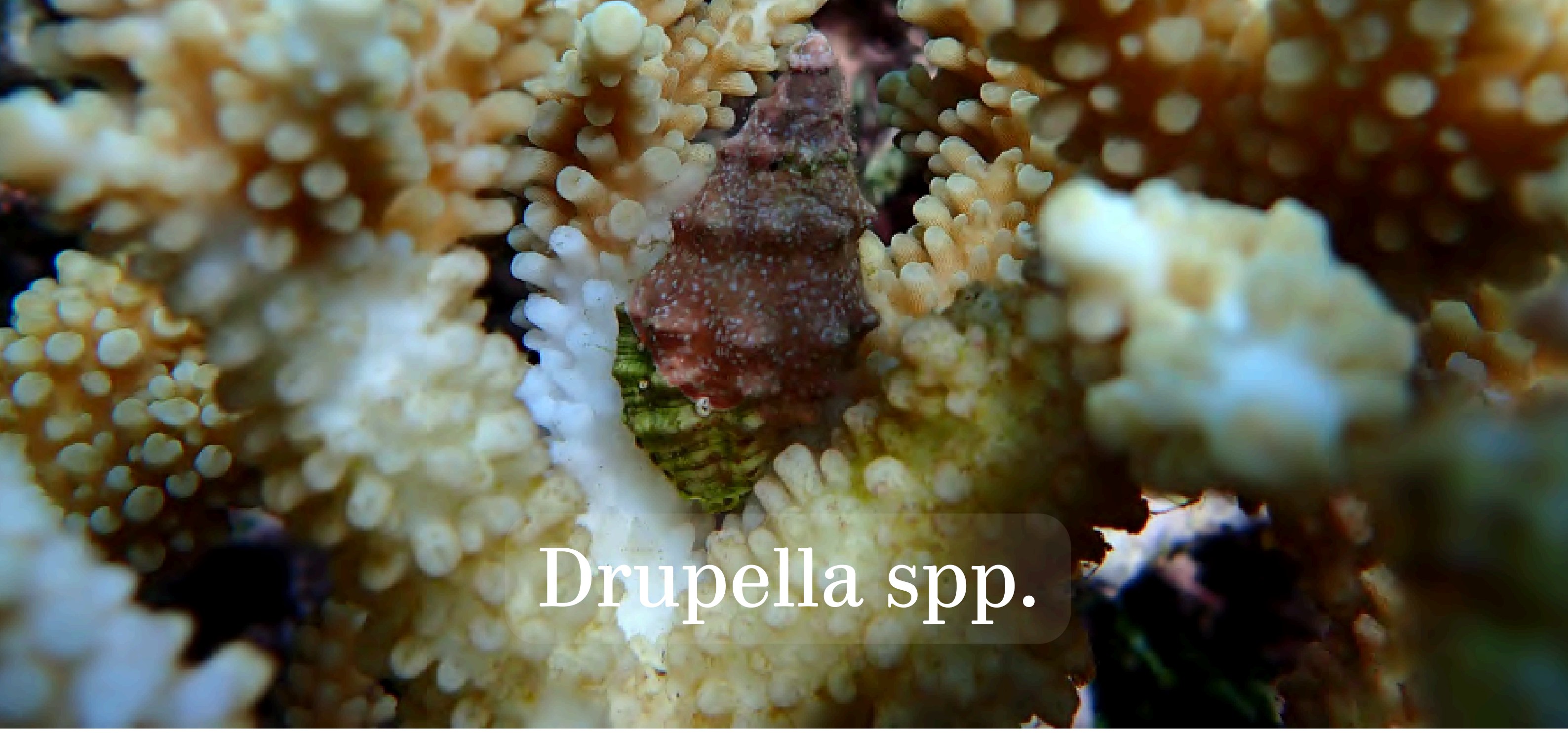


Figure 6. A) Mean abundance of *Porites* Ulcerative White Spot (PUWS) per 100m^2 for survey site Poblacion II, B) Mean area infected by PUWS per 100m^2 measured in m^2, and C) Mean proportion of 100m^2 of *Porites* spp., Turf Algae, Newly Dead Coral, Dead Coral with Algae throughout 2019-2023 for survey site Poblacion II.

Further PUWS Research

IMR will continue to monitor the spread of PUWS bi-annually throughout the DLTRMP, and gain further understanding on the mortality rates of the disease to determine the severity of the impact. Furthermore, IMR plans to conduct a study in situ regarding the transmission of PUWS, alongside the long term monitoring of select colonies. The cause behind the disease transmission is not immediately clear, with studies showing that colonies can reside adjacent to infected colonies without obvious infection by PUWS over the course of long term studies (>17 months) (1). It is thought that some bacteria that live naturally inside coral colonies have an antipathogenic effect on PUWS (3).



Drupella spp.

Coral Predation from Drupella spp. Aggregations

Drupella spp. are a species of corallivorous snail native to the Indo-Pacific region (6). There are three main species, *D. cornus*, *fragum*, and *rugosa*. Their preferred prey is branching Acroporid species of hard coral followed by other branching hard corals. *D. cornus* and *fragum* are found mostly on the reef crests and exposed reefs, in contrast to *D. rugosa* which prefers more sheltered environments (7).

It is possible for the populations of these snails to rise to unsustainable levels, causing significant mortality, first reported in 1982 (8–11). Density of these outbreaks vary, from 2.85 individuals/m^2 to 19.4/m^2 (9,11), but they can have devastating impacts on the hard coral populations, in turn affecting the rest of the coral reef ecosystem. However, *Drupella* spp. also exhibit a behaviour called 'Large Aggregations', in which hundreds, sometimes thousands, of individuals gather (7). These occur in all three species (8,9), and are a common feature of population dynamics (7). This makes establishing the difference between an outbreak and a large aggregation difficult. Large aggregations tend to be more short term, with Cumming *et al.* defining a *Drupella* spp. outbreak as elevated population densities that have persistent and extensive mortality of corals over months or years (7). There is some variation within species, and historically *D. fragum* and *cornus* more commonly have population outbreaks and *D. rugosa* have more large aggregations. This is possibly linked with their preferred habitats.

IMR monitors predation from *Drupella* spp. on our surveys to track the impact of the predation on the hard coral populations and remain vigilant for any potential outbreaks. They are measured through the mean frequency of colonies predated on by *Drupella* spp. per 100m^2 and mean size of feeding scars per 100m^2. Due to the cryptic nature of the snails, it is currently difficult to count the number of individuals from photos taken during IMR's surveys.

2023 Drupella Status

The most common coral genera that *Drupella* spp. predated on was *Acropora* spp. and *Pocillopora* spp. per 100m^2 with a mean frequency of colonies predated on of 3.3 and 1.5/100m^2 respectively (**Figure 7**). In 2022 we saw a drop in the preferred feeding species, and *Stylophora* spp and *Anacropora* spp. rose in mean frequency of instances of *Drupella* spp. predation to 4 and 3 per 100m^2. This is due to instances of high feeding activity by *Drupella* spp. at Poblacion II and Masaplod Sur MPA respectively. Studies show that *Drupella* spp. will feed on alternative branching species if its preferred prey of *Acropora* spp. are not available (7). Masaplod Sur MPA was in the midst of a Crown of Thorns Starfish (COTS) outbreak during 2022 (see COTS section for more information) and so there would have been high competition for *Acropora* spp.. *Pocillopora* spp. has decreased as prey for *Drupella* spp. since its peak in 2021 at mean frequency of 3/100m^2 to 1.5/100m^2 but is still the second most common prey for *Drupella* spp. after *Acropora* spp. In terms of mean frequency by location, we found a large number of *Drupella* spp. predation at Lipayo I Sur during Wet season 2023 with 15/100m^2, up from 3.5/100m^2. Lipayo II also saw an increase in incidences of *Drupella* spp. predation.

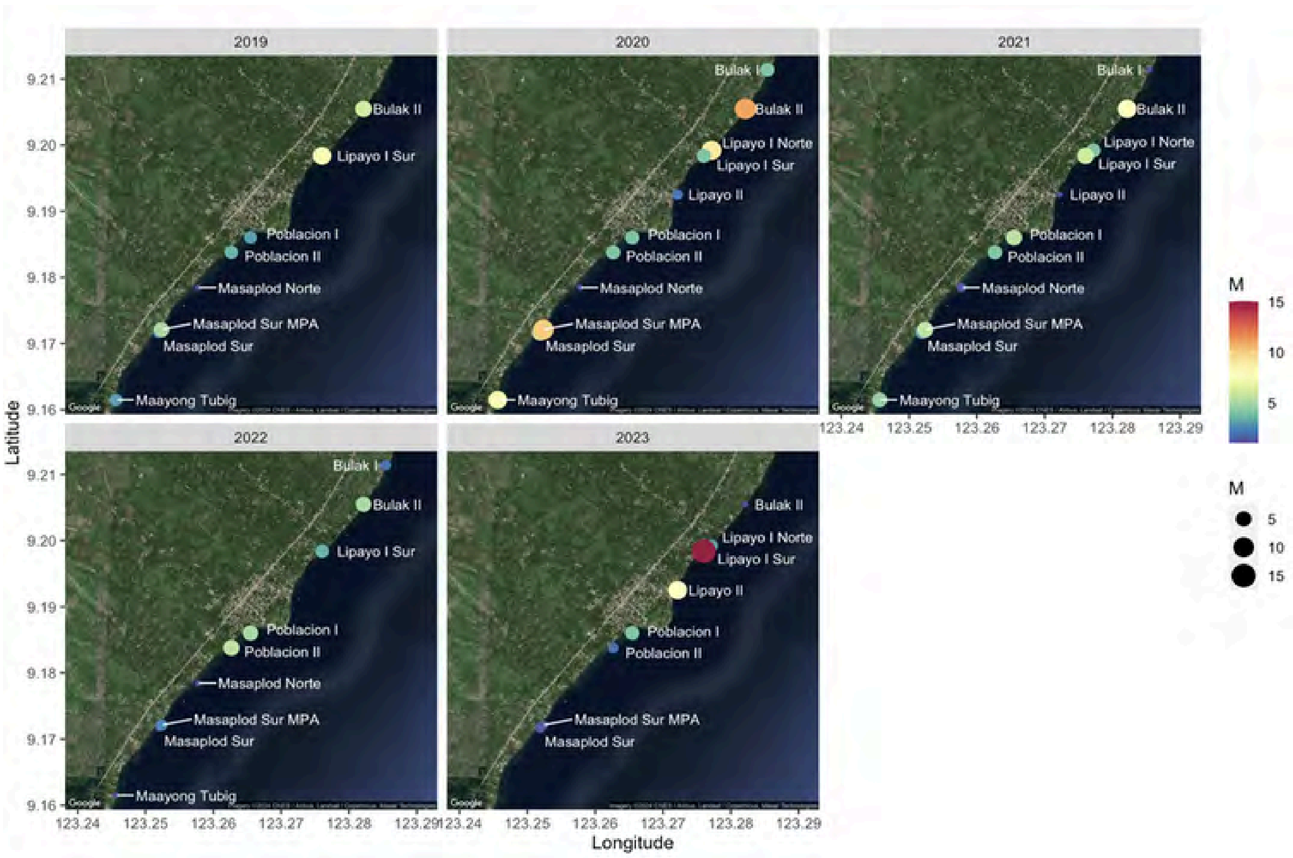


Figure 7: Mean abundance of *Drupella* spp. predation per 100m^2 as size and colour by survey location from 2019-2023.

Site Spotlight: Lipayo I Sur

Lipayo I Sur is a marine sanctuary located within the barangay of Lipayo. In 2023 Wet season, Lipayo I Sur had the highest of *Drupella* spp. instances of our survey sites, with a mean frequency of colonies affected 15/100m^2 from 2/100m^2 in the Dry season (**Figure 8**). 86% of these instances were *Drupella* spp. predating on *Acropora* spp. and the remainder on *Pocillopora* spp.. Mean area predated upon per 100m^2 was only 5cm^2 per colony, however, so we did not see enough predation to surpass our outbreak proxy level of 3m^2 of affected coral per 100m^2. Further monitoring in 2024 will show whether there was any long-term impact on the reef from *Drupella* spp. or if the situation led to outbreak status.

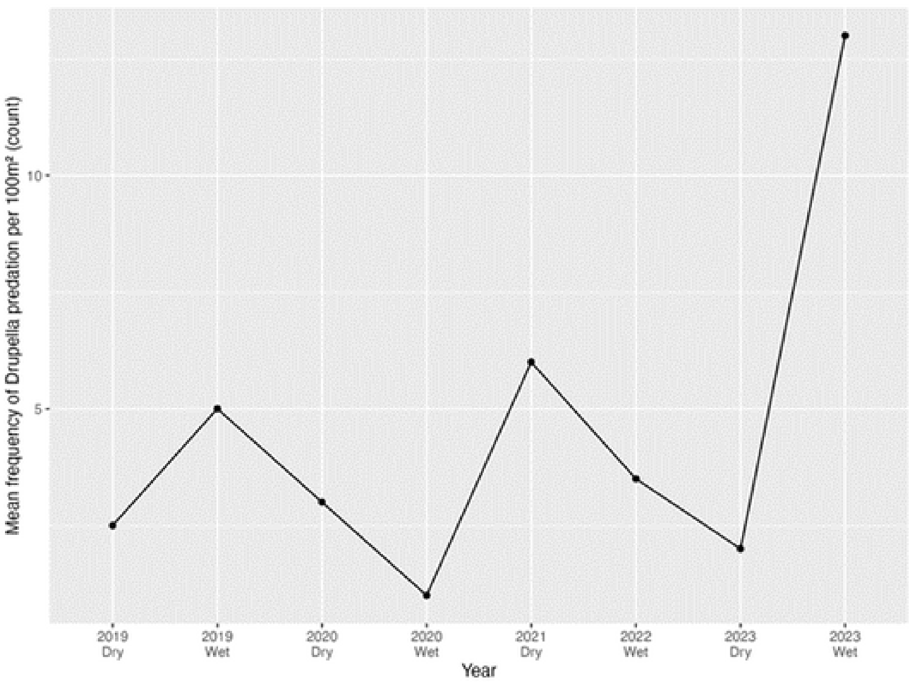


Figure 8: Mean abundance of *Drupella* spp. predation per 100m^2 as size and colour by survey location from 2019-2023.

Further Drupella Research

In light of the recent concerns for *Drupella* spp. outbreaks in Dauin, IMR will start to monitor key sites for *Drupella* spp. outbreaks using in situ monitoring methods to evaluate populations levels as per the recommendations laid out by Cumming *et al*. (7). This will include regular monitoring of key sites where there are elevated populations of *Drupella* spp. are seen, and sites in which there are large amounts of *Acropora* spp. in areas of the reef which are not covered by our transects (ie. reefs shallower than 5m).

Coral Bleaching

Municipality of Dauin

The site with the highest mean frequency of colonies recorded per $100m^2$ by the end of 2023 was Poblacion II with $24.5/100m^2$ (**Figure 9**). The most common genera of hard coral in 2023 was *Pocillopora* spp. with a mean frequency of $28/100m^2$ followed by *Anacropora* spp. with $26/100m^2$. As temperatures increase, there is a need to continue monitoring for bleaching in case of mass bleaching events reaching Dauin.

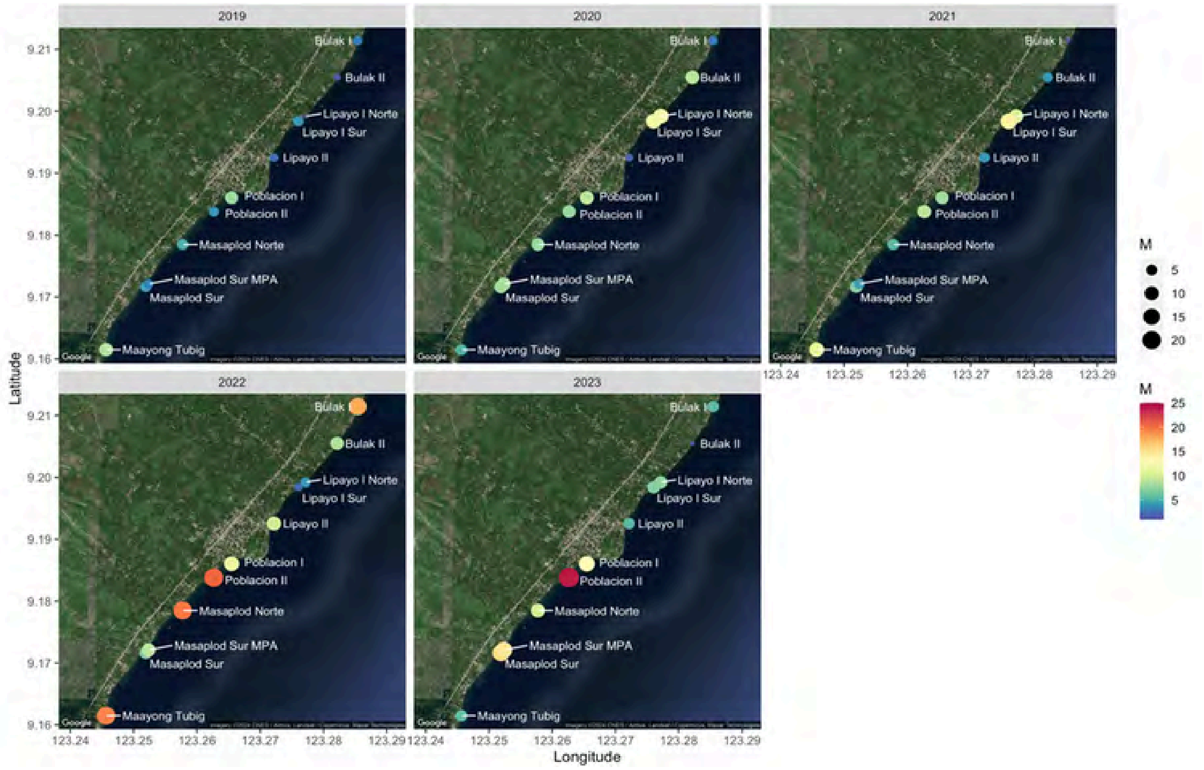


Figure 9: Mean abundance of *Drupella* spp. predation per $100m^2$ as size and colour by survey location from 2019-2023.

Crown of Thorns Starfish (Acanthaster plancii)

Municipality of Dauin

The Indo-Pacific is home to the notorious coral eating *Acanthaster* spp., also known as Crown of Thorns Starfish (COTS). When occurring in low numbers these natural predators can be part of a healthy coral reef ecosystem. However, an outbreak of COTS can be devastating. Research shows that COTS are a major cause of coral mortality which can have significant impacts on fish populations, benthic diversity, and reef complexity (15,16). Currently the parameters defining an outbreak vary among studies with no standard global classification. IMR describes an outbreak as more than 1 COTS per $50m^2$.

In 2023 over 800 individual COTS were reported along the Dauin coastline. Only 4 of these were recorded within survey transect lines: 3 at Lipayo Sur and 1 at Maayong Tubig. An additional 8 scars, thought to be caused by COTS, were documented at various sites but no individuals were seen to confirm this. Three sites were repeatedly targeted by high numbers of COTS; Poblacion I, Masaplod Sur and Maayong Tubig (**Figure 10**). All three of these sites are registered marine protected areas, Poblacion I was designated in 1995, Maayong Tubig in 2000, and Masaplod Sur in 2002.

Outbreak Intervention

To manage the damage caused by high densities of COTS, human intervention may be necessary to control populations. Culling COTS during outbreaks is a common practice happening all over the world with many different techniques being used (15,17). The Institute for Marine Research administers vinegar injections (**Figure 10**) which disrupts the internal pH of the COTS (16,18). This is a well-tested and low risk technique for managing outbreaks. During a COTS cull the number of individuals killed is documented, in addition to this, any COTS that were seen, but were unreachable, are also recorded.

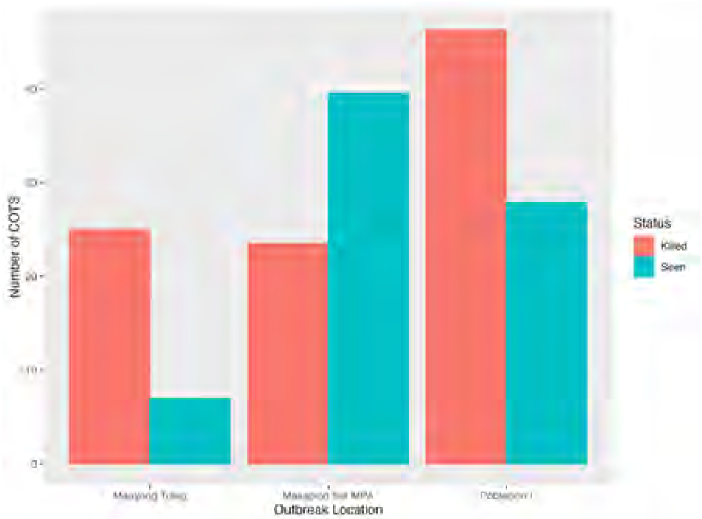


Figure 10: Count of COTS injected ("Killed"), and seen but not reachable for injection ("Seen") during IMRs outbreak intervention efforts.

Causes of COTS outbreaks have been debated for decades and are thought to vary by region depending on environmental conditions and human impacts. A widely accepted cause is the overfishing of the COTS' natural predator: Titan triggerfish (*Balistoides viridescens*) and Triton snails (*Charonia tritonis*) (19,20). Excluding Apo Island, the Dauin coastline is made up of 9 marine protected areas (MPAS) each governed by the local Bantay Dagat, also known as the Sea Guardians (Source: Marine Protected Area Management Plan 2008-2012, Municipality of Dauin, Negros Oriental, Philippines). These areas have had restricted fishing practices for over 20 years. Research into the effectiveness of these areas is limited, and unfortunately, even in marine protected areas, Triton snails are now considered rare and endangered due to historic overfishing and low recovery rates (20). Therefore, further population studies would be needed to confirm if their absence is influencing COTS outbreaks.

Another recognised theory is that environmental conditions, such as an increase in nutrient levels, can promote the survival of COTS larvae (21,22). Management of agricultural run-off and household waste disposal is limited in the Philippines resulting in many polluted rivers and coastal waters (23). Environmental assessments along the Dauin coastline would need to be completed to further investigate if increased nutrient levels coincide with COTS outbreaks.

Studies have shown strong correlations between prey abundance and density of COTS (24). Poblacion I, Masaplod Sur and Maayong Tubig are all home to numerous *Acropora* spp. which are the preferred prey of COTS, they also host a variety of other coral genera which COTS prey on such as *Pocillopora* spp. and *Montipora* spp. (**Figure 11**) (25,26) .

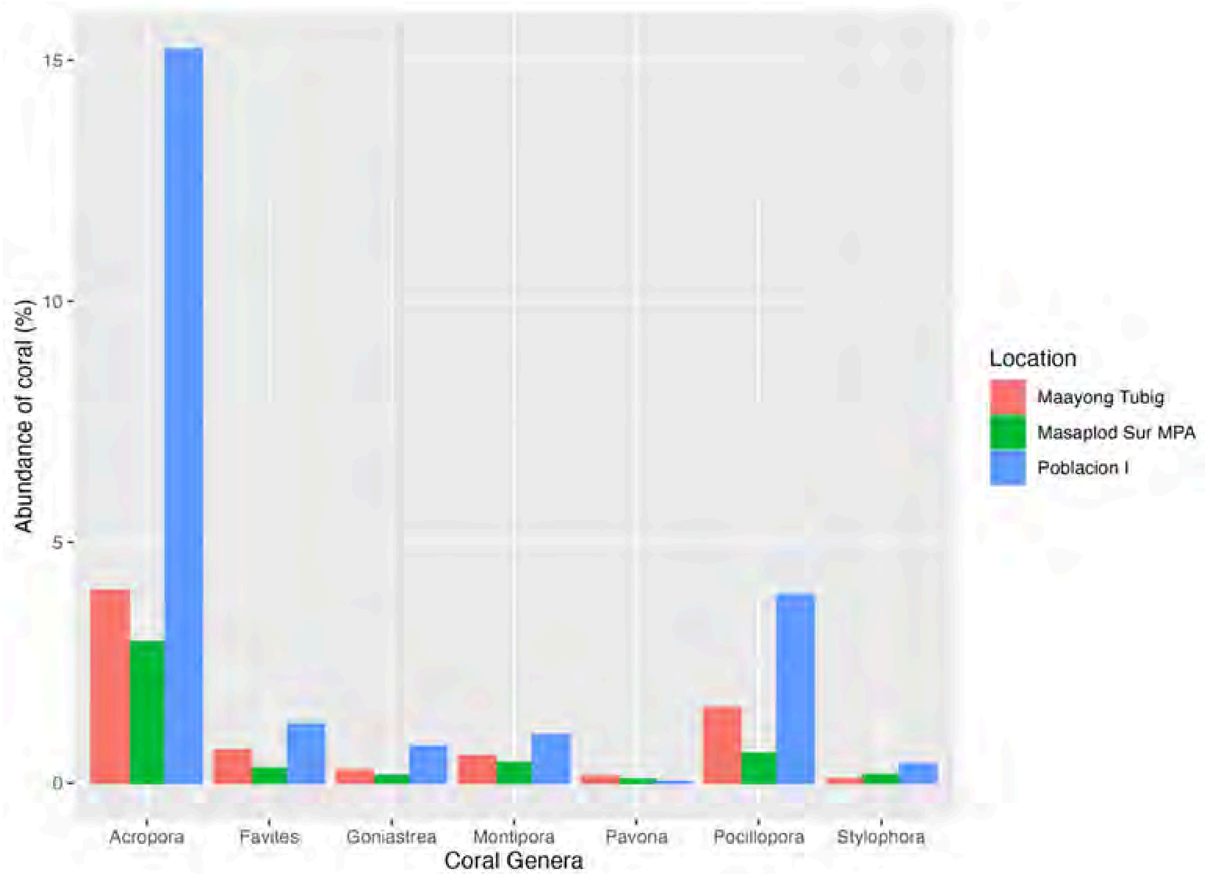


Figure 11. COTS feeding preference across 7 coral genera, and 3 surveyed locations (Maayong Tubig, Poblacion and Masaplod Sur).


SCUBAPRO

Municipality of Dauin

Trash in our oceans, or marine debris, is a threat that faces all marine habitats all over the world (27). It is a cause for concern for several reasons; it is known to be harmful to marine organisms (28), and can have the potential to increase the spread of organic and inorganic pollutants (29,30). It is estimated that plastic debris accounts for 92% of encounters between marine life and debris (28). Debris from fishing, also known as ghost fishing gear, is fishing equipment including line and nets, that are lost in the ocean during fishing activities. These are especially dangerous for marine life due risks of entanglement and ingestion (31–33). It is also a risk for damaging marine habitats (34). It is a significant source of marine debris, but due to its nature it is challenging to quantify fishing debris (35,36). It is estimated that 5.7% of all fishing nets, 8.6% of all traps, and 29% of all lines are lost globally each year (35).

IMR monitors for trash throughout our survey transects in Dauin, differentiating between General Trash and Fishing Trash (**Figure 12**). There was a spike in both General and Fishing Trash post Covid-19 pandemic until the end of 2022. Due to the demand for personal protective equipment (PPE) during the Covid-19 pandemic which began in 2020, many of the single-use plastics involved have ended up in marine and freshwater environments (37,38). This would explain the increase in general trash found in 2021 and 2022. Furthermore, during the closure of the Philippines, fishing trash to a peak of 96 in 2022.

Fortunately, in 2023, we have seen a decline in both kinds of marine debris, with fishing trash occurring at a total of 27 pieces found in 2023, and 24 pieces of general trash. This is down from 96 and 43, respectively, in 2022.

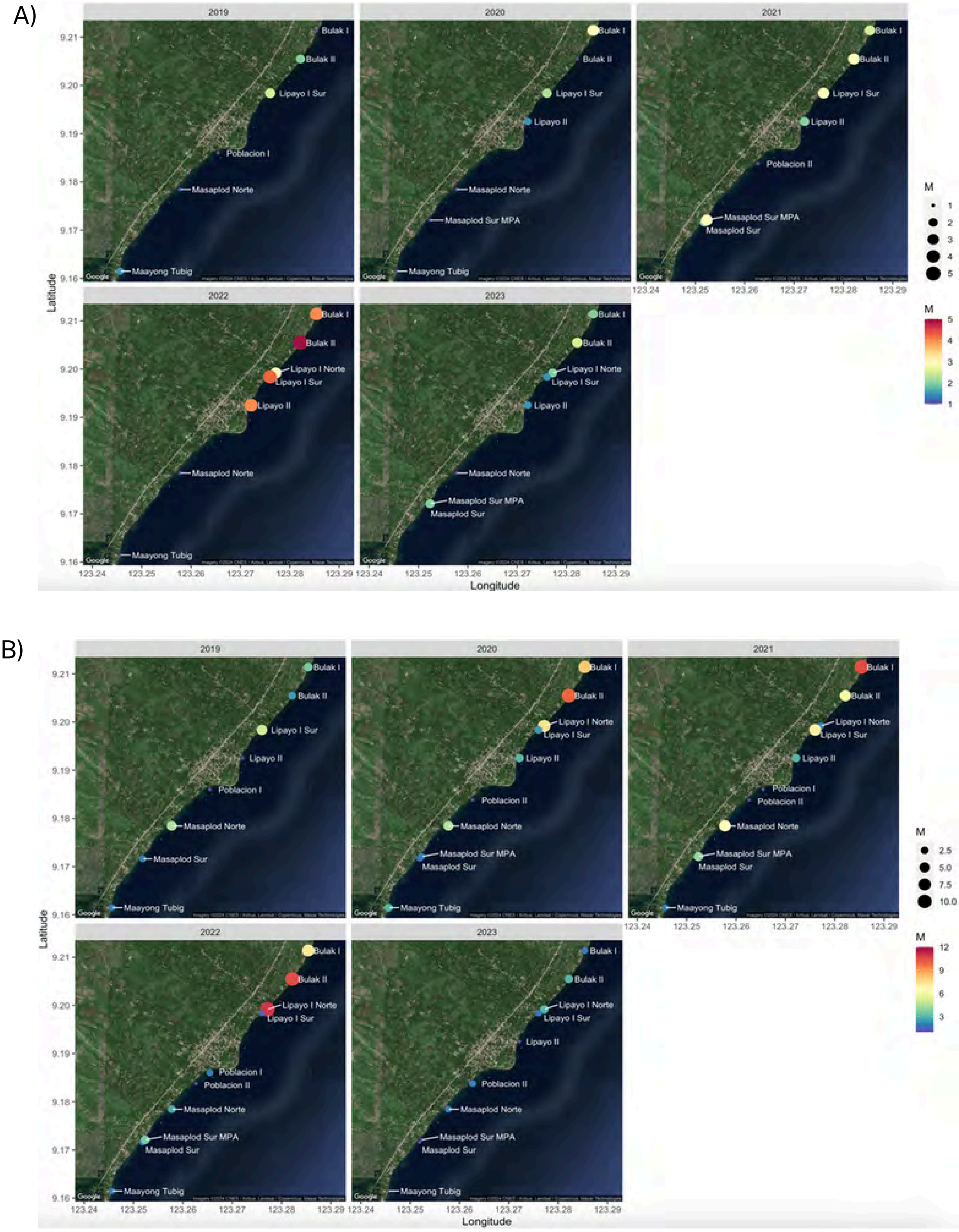


Figure 12. Count of trash prevalence across IMRs survey sites, separated into a) general trash, and b) fishing trash.

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